SHRINK HEMMING OF ALUMINUM ALLOY SHEET METAL

Makoto Murata and Takao Nada
Department of Mechanical and Control Engineering
University of Electro–Communications , Tokyo 182 Japan

ABSTRACT

Hemming, which is folding the edge of sheet metal to 180 degrees or more, is one kind of bending methods in sheet metal forming. The aims of hemming are joining one metal sheet to another, improving the appearance of the edge and adding slightly to the rigidity of the edge. For example, hemming is applied to car frames for joining the inner panel to the outer panel such as door panels.

The hemming mechanism is complex. Hemming technology has been developed by many technicians with abundant experience in many trials and errors. Therefore, there have been few studies of theories and experimental data about hemming. It is said that aluminum sheets are used in door panels for reducing of the car weight in the automobile industry field. There are no reports on hemming of aluminum sheets. Therefore, the deformations and defects of shrink hemming are experimentally examined using aluminum sheets as worksheets and the mechanism of the hemming is made clear in this paper.

Keywords: *metal forming, bending, sheet metal, shrink hemming*

1. INTRODUCTION

Hemming is one of the most important methods of sheet metal forming. However, there have been few studies of theoretical and experimental papers about it. In this study, the authors intend to test flat-shrink-hemming on three stages of the hemming process using aluminum sheets and examining experimentally the characters and defects on the forming conditions in each process.

2. EXPERIMENTAL EQUIPMENT

Figure 1 shows the three stages of the hemming process. A worksheet is bent to an angle of 90 degrees on flanging by a flanging die, which is loaded by a punch in the arrow direction in the first stage as shown in Fig.(A). The worksheet, which is bent at 90 degrees, is bent 45 degrees further in pre-hemming in the second stage as shown in Fig.(B). The bent worksheet is bent 45 degrees

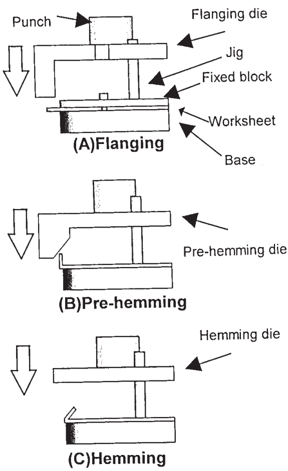


Fig.1 Three stages of hemming process

further and the total bending angle is 180 degrees in the hemming in the third stage as shown in Fig.(C).The dies and bases are made of 0.55% carbon steel (S55C). The dimensions and shapes of the worksheet are shown in Fig.2 and Fig.3. The worksheet is aluminum A5182 and it's thickness is t_0 = 1.0 mm. The bottom bending radii R_{sh} changes from 300 mm to 1200 mm and the flange height H changes from 4 mm to 20 mm as shown in Fig.2.

3. EXAMINATION RESULTS

3.1 Limitation of hemming

The limitation of the hemming is shown in Fig.4 at relationships between the bottom bending radius R_{sh} and the flange height H. As the bending line shapes are arcs and the flange parts receive compression forces such as for the shrink flange, wrinkles occur at flange. Photo1 shows an example of the wrinkles. As the flange height becomes higher and the bottom bending radius becomes smaller, the wrinkle is liable to occur. When the flange height is H = 4 mm, the flange worksheet can not be pre-hemmed. Because the springback angle is large at H = 4 mm after flanging.

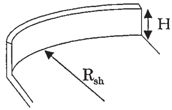


Fig.3 Ketch of flanging

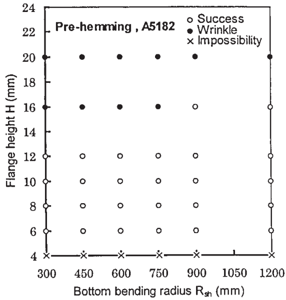
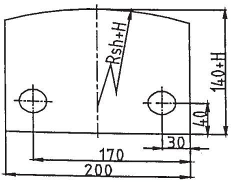


Fig.4 Hemming limitation as functions of bottom bending radius and flange height



R_{sh}=300,450,600,750,900,1200

H=4,6,8,10,12,16,20

Fig.2 Dimensions and shapes of worksheets

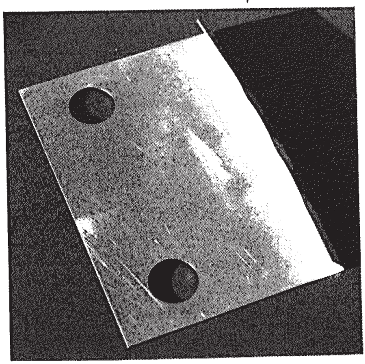


Photo.1 Example of wrinkle in pre-hemming

3.2 Press load P_h

Figure 5 shows the relationships between the flanging load P_h and stroke S in wrapped bending at flanging. After the flanging die touches the worksheet, P_h begins to rise. All P_h's reach peak values at about stroke = 5 mm in spite of changes of R_{sh} dimensions. The reason is explained in Fig.6 as follows. C is the length between the loading point and the base shoulder, and the radius of the die shoulder is 5 mm. Therefore the loading point moves from the point A to the point B when the stroke becomes more than 5 mm, and C has minimum values. As the bottom bending radius R_{sh} decreases, the peak load increases, because the arc length of the bend line becomes longer with the decreasing of R_{sh}.

The relationships between the pre-hemming load P_h and the stroke S are indicated in Fig.7. When pre-hemming die touches the worksheet, the load P_h increases and reaches peak value. The shorter flange height H is, the larger the peak value becomes. Because the length of the truss of the moment decreases in proportion to shortening of H. As the bending angle increases with increasing the length of the truss of moment after reaching the

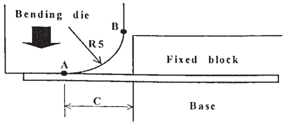


Fig.6 Outline profile at flanging

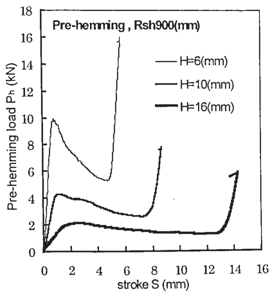


Fig.7 Pre-hemming load and stroke

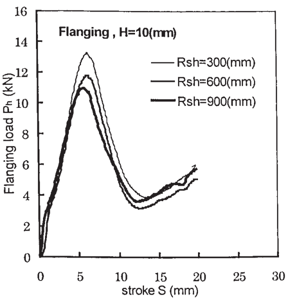


Fig.5 Flanging load and stroke

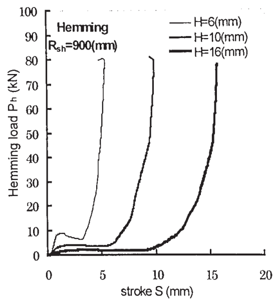


Fig.8 Hemming load and stroke

peak value, P_h decreases. When the bending angle reaches about 135 degrees and the flange clings to the oblique side of the pre-hemming die, the load rises again. The load-stroke curves indicate almost same figure in spite of the changes of R_{sh} dimensions..

Figure 8 shows the hemming load - stroke curves. After the die touches the worksheet, the load begins to rise and reaches peak value. The shorter H is, the larger the peak value is, for the same reason as pre-hemming. After P_h reaches peak value, the P_h decreases slightly or is constant. When the bending angle increases and the flange touches the web, P_h rises suddenly. The load-stroke curves indicate almost the same figures in spite of the changing of the R_{sh} dimensions.

3.3 Flange angle

The relationships between the flange angle θ and flange height H are shown in Fig.9. The flange angle θ is the angle between the web and the flange at center of the worksheet, as indicated in Fig.10. The flange angle of H=4.0 mm is larger than others of more than H=4.0 mm. Therefore the worksheet of H=4.0 mm can not been pre-hemmed. As H increases, the springback decreases and θ decreases.

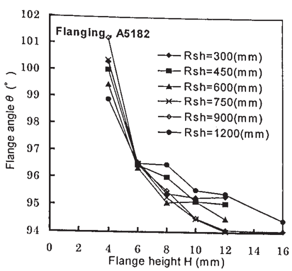


Fig.9 Flange angle and flange height as a function of bottom bending radius

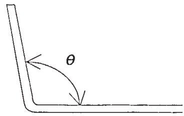


Fig.10 Shape of flange angle

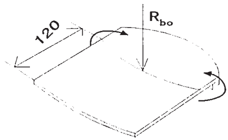


Fig.11 Outline of Rbo

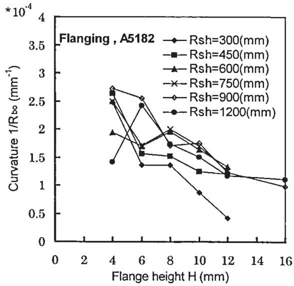


Fig.12 Curvature of bottom sheet at flanging

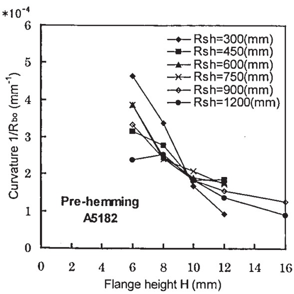


Fig.13 Curvature of web at pre-hemming

3.4 Deformation of bottom sheet

The web of the bottom sheet receives the bending moment, which is indicated in the arrow direction, therefore it is curved as shown in Fig.11. The radius of the web is R_{bo}. This moment occurs by compression force, when the flange is compressed. Figure 12 indicates the relationships between the flange height H and the curvature of the web after flanging. As H increases, the curvature decreases. Because, the rigidity of flanging part becomes larger, as H is increases and the curvature of the web is prevented from increasing. Therefore, the curvature of the web is prevented from increasing in pre-hemming for the same reason as the flanging as shown in Fig.13, as the flange height becomes larger. Since the flexural rigidity of the flange becomes smaller in hemming, all the curvatures have the same values in spite of the changes of the flange height, as shown in Fig.14.

3.5 Profile

Figure 15 presents the profile of bent line at the flanging, pre-hemming and hemming. D_{center} is the length from the center of worksheet and D_{edge} is the length from the edge which isn't bent to the bent

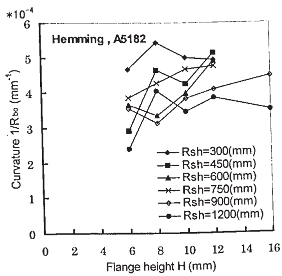


Fig.14 Curvature of web at hemming

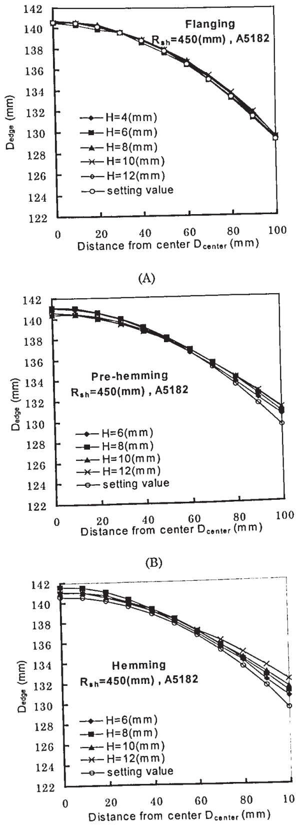


Fig.15 Profile of bend line

line as shown in Fig.16. All the profiles of the bent line are similar to the setting line at flanging as shown in Fig15(A). The profiles of the bend lines move toward the outside at the center position and the edge position in pre-hemming and hemming. The hemmed worksheet receives a compression force at the center of the bent line on the flanging. The hemmed worksheet does not receive a constrained force and is free at the edge of bent line.

The radius of the bent line R_{ec} is shown at hemming in Fig.16. Figure 17 indicates the relationships between R_{ec} and the flange height H as a function of the bottom bending radius R_{sh}. All radii R_{ec} are larger than setting radii R_{sh}. As H increases, R_{ec} increases as a function of the setting radius R_{sh}.

4. CONCLUTION

The deformations of hemming were experimentally examined using aluminum worksheets. The characteristics of flat hemming were made by the authors. The results are shown as follows;

(1).As the flange height became higher and the bottom bending radius became smaller, the wrinkle is liable to occur.

(2).The relationships between flanging load and stroke were influenced by the changes of the bottom bending radius R_{sh} and the flange height H. The relationships between the pre-hemming load and the hemming load were influenced by the changes of the flange height in spite of changes in the bottom bending radius R_{sh}.

(3).The deformations of the bottom sheet decreased with the flange height H increasing, in spite of changes of the bottom bending radius R_{sh} in flanging and pre-hemming. The deformations of the bottom sheet were the same as in the hemming.

(4).The profiles of the bent lines moved toward outside at the center position and the edge position of the worksheet at pre-hemming and hemming. The radii of bent line R_{ec} increased, as the flange height H increased.

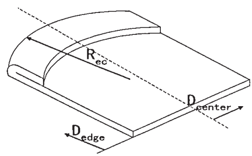


Fig.16 Outline of hemming

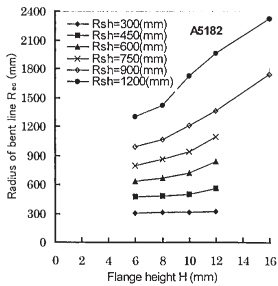


Fig.17 Radius of bent line at hemmed

REFERENCES

[1] M.Attila., M. Murata, at et al, 1996, "Bending, Flanging, and Hemming of sheet-an experimental study", J.Materials Processing Technology, 59,10-17

[2] T.Matida, 1993, "Parts and Recent trends of joining and composite in productive technique ", J.JSTP, vol34-391, pp856-864